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A STUDY OF FACTORS AFFECTING THE

PALATABILITY OF HOME DEHYDRATED APPLES

by

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3650

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M. J. D.

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CHAPTER I

INTRODUCTION

The preservation of foods by drying has been used for many centuries. Perhaps nature was man's first teacher in this art; the animals stored their foods in summer for winter, and some trees and vines held their fruits until dry, thus, no doubt, suggesting this method to man. It was known to the Egyptians, Israelites, and Arabs, who dried figs, grapes, olives and dates.

Early American settlers prepared a product called "Samp", sweet corn cut from the cob and dried by the sun; also fruits and meats were preserved by drying.

War seems to have been the most stimulating factor in the production of dehydrated foods. During the Civil War dried vegetables, such as potatoes, mixed vegetables, and apples were pressed into briquette forms after drying and used by the Union Armies for the purpose of preventing scurvy. The flavor was so disagreeable the men refused to eat them. Present day methods of pretreatment and storage to preserve flavor were not known at that time.

During World War I about nine million pounds of dehydrated vegetables were shipped overseas. They were most unpopular as they were tough and poor, if not actually disagreeable in flavor and odor, and unattractive in appearance when cooked. The only pretreatment was blanching of potatoes. In contrast to these unsuccessful attempts with vegetables, dried fruits, such as raisins, prunes and figs, have been acceptable foods for centuries.

Since we have again become involved in a world conflict the demand for food has been so great that every available method of preservation has been pressed into use. It has also become very important to conserve shipping space, to reduce weight, and to develop new types of containers which will not require essential war materials. Hence commercial dehydration has greatly expanded.

In 1940 the Bureau of Agriculture and Industrial Chemistry started new investigations on dehydrated foods. The objectives were to discover, (1) methods of decreasing the weight of foods, (2) ways of saving shipping space, (3) new types of containers, (4) how to lengthen storage life of dehydrated products, and (5) techniques for retention of the greatest possible nutritive value of the foods. Such research has made present day dehydrated foods far superior to those of the past. It has been estimated that dehydration has saved the shipping of three million tons of water that would have been in the fresh food. According to Mrak, the weight is reduced in dehydration to from one-eighteenth to one-fifth that of the fresh food, and the volume is reduced to from one-third to one-ninth.

The war has also made home food conservation a necessity, for two reasons, (1) that no food be wasted, and (2) that the home do its share in carrying out the food conservation program. Dehydration makes it possible to save much food which would otherwise go to waste for lack of equipment and containers needed for other methods of preservation. Some time after commercial dehydration received its stimulus home dehydration was urged as a solution to the wartime civilian food preservation supply problem. Thus far the home method is largely in the experimental stage, the production of an efficient and inexpensive dehydrator for home use being a major problem. The case was brought before the War Production Board and Senate committees until materials were set aside for building 100,000 electric home dehydrators during 1943. Additional research is needed to improve pretreatment techniques and better packaging and storage methods so that dehydrated foods will have quality that can compete with that obtained by other forms of food preservation. Much of this research is now underway. Home dehydration has greatly aroused the interest of investigators in food research. The United States Department of Agriculture and Experiment Stations of many state colleges have issued bulletins with information on home dehydration. The manufacturers, who look for the opportunity of developing and handling new products, are interested in placing on the market an efficient home dehydrator. The National Dehydration Association is also concerned that home dehydrated products be of the best quality, since their post war plans are to convert their industry to civilian use, and the creation of a favorable attitude towards dehydrated products is important.

Henderson summarizes results of a survey of home dehydrator users, thirty interviewed personally, and others contacted by mail. They have had from one to four months experience. While the results are not conclusive, they do give an idea of how users are thinking. In general they believe that (1) it is less trouble to dehydrate than to can, (2) dehydration is well adapted to areas where cellar storage is lacking, (3) dehydrated products are much higher in quality than sun or stove dried products, (4) small light weight containers are desirable for families who move often, and where storage space is limited, (5) dehydration costs less than canning, (6) some products such as corn, peas, and green beans can be kept with less risk of loss as compared with canning even when a pressure cooker is used.

In contrast, the same report lists the following points against dehydration: (1) commercially constructed dehydrators cost too much, (2) sulfuring of fruit is too much trouble and sometimes a disagreeable task, (3) many have had the experience of uneven drying on the trays from top to bottom, (4) instructions for preparation of products, operating the dehydrator, packaging, storing and refreshing are not consistent and in most instances inadequate, (5) dehydration in its present development is a "war baby", (6) in planning meals allowance has to be made for a longer period of preparation.

Combining the results of this survey with field observations and laboratory experience Henderson concludes that:

(1) Some users will be dissatisfied when they use their products because, (a) they did a poor job of one or all of the steps in the processing, frequently laboring under false impressions or misinformation, (b) some are inclined to can or freeze the best product and dehydrate the poorest, (c) products were stored in too warm a place and improperly packaged.

(2) As compared with freezing, home dehydration techniques can be further simplified and improved; to compete with canning as a method of preservation the dehydration process must be simplified and the quality must be equal or be superior, to offset the inconvenience of a long preparation period before serving.

(3) Technique in refreshing is definitely lacking with new users. Education and experience will greatly overcome this.

(4) Additional research is needed in all steps of the process.

(5) Marketing at a low cost ($25.00 or less) an efficient, attractive dehydrator as nearly automatic as possible, with effective instructions, will greatly enhance the chances of dehydration becoming popular (manufacturers think this is possible).

(6) Dehydration ranks first in low cost food processing. According to available figures - freezing $9.00 per 100 quarts in the home, canning $3.50 per 100 quarts in the home, dehydration $2.70 per 100 quarts in the home. All costs are exclusive of labor.

In the very rapid development of food dehydration processes, both commercially and in the home, many problems have arisen. None are more important than the preservation of palatability and nutritive value. Flavor is one of the first requisites of any food consumed by man. No matter how attractive in appearance, how inexpensive or nutritious the food may be, if it is not pleasing to the taste, it has little chance for popularity.

The purpose of this study is to investigate factors which influence the flavor of dehydrated apples and to find which of the recommended methods is most desirable for home use.

CHAPTER II

REVIEW OF LITERATURE

In reviewing the studies dealing with dehydration of fruits, it is apparent that while some research has been done, published results are concerned primarily with appearance and keeping qualities, rather than palatability. Since such fruits as raisins, prunes, peaches, and apples have long been accepted as satisfactory for drying, investigators have turned most of their attention to the more difficult problem of drying vegetables.

Fisher states that the palatability of the home dehydrated foods depends upon, (1) the freshness of the fresh product, (2) the efficiency and care in using the dehydrator, (3) the degree of control maintained over time, temperature, humidity, and other variables.

Factors which influence quality and palatability begin with the kind of fruit itself. According to most authorities late maturing, good cooking varieties should be used.

Woodroof states: "The kinds and varieties of fruits suitable for dehydration are usually, (a) highly flavored, (b) highly colored, (c) quite acid, (d) quite sweet, and (e) firm."[1]

Caldwell indicates that a good dessert or cooking apple makes a superior evaporated fruit, since the distinctive flavors are well retained through the drying process. Most summer and early maturing varieties give a low yield which is light in color and attractive in appearance, but de-

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[1] J. W. Woodroof, W. E. DuPree, and Helen H. Thompson, Dehydration of Fruits and Vegetables and Utilization of Dehydrated Products. Georgia Experiment Station Bulletin 225. (February, 1943), p. 9.

teriorates quickly in storage as well as lacks sweetness and distinctive flavor when cooked. Autumn and winter apples are best because they are richer in flavor and produce a larger yield of the dehydrated product for the same labor and money.

Table I gives the varieties of apples recommended for dehydration.

Fruits for dehydration should not be picked until they reach the firm-ripe state. Fruit that is even slightly green should never be dehydrated because: (1) it contains considerable starch that changes to sugar on ripening, (2) the finished product has a dull, withered appearance, (3) it does not rehydrate readily or completely.

Only high quality fruit should be dehydrated, because the dried fruit is dependent for its quality upon the quality of the fresh product. To prevent bruises and other losses of the fresh fruit great care must be taken in handling and storing before processing. To retain the fresh qualities speed in handling from harvesting to storage is an essential factor.

Eidt proves from numerous experiments that small apples are uneconomical for dehydration because: (1) there are many more apples to handle in small sizes than in larger sizes, (2) the waste is greater, (3) there is a smaller percentage of whole rings and less uniformity of the rings. Grading according to size and quality is an advantage to commercial dehydration since it makes possible the sale of fruits on a grade and weight basis. Woodroof points out the economy of grading apples according to size for speed in handling and uniformity of product. This is a point that should not be overlooked in choosing apples for home dehydration.

Region, soil, climate and cultivation have an effect on the quality of the fruit, which in turn affects the quality of the dehydrated product,

TABLE I

VARIETIES OF APPLES RECOMMENDED FOR DEHYDRATION

Varieties:	Recommended by:
Baldwin	Eidt, Editorial,* Von Loesecke
Ben Davis	Eidt, Von Loesecke
Delicious	Caldwell
Esopus	Caldwell, Von Loesecke
Fallawater	Eidt
Golden Delicious	Caldwell
Golden Russet	Caldwell
Grimes	Caldwell
Gravenstein	Eidt, Von Loesecke
Jonathan	Caldwell
King	Eidt, Von Loesecke
Nonpareil	Eidt
Northern Spy	Eidt, Caldwell
Rome Beauty	Eidt, Caldwell, Editoral*
Roxbury Russet	Caldwell
Stayman Winesap	Caldwell, Editoral*
Wagner	Caldwell, Eidt, Von Loesecke
Winesap	Caldwell
Yellow Newtown	Caldwell, Von Loesecke

* Fruit Products Journal XXI, May 1942, 279.

but comprehensive studies of these factors are not available.

All writers emphasize the necessity of using only fresh, mature, sound fruit for best flavor and yield in the finished product. The quality of the dehydrated fruit will not be better than that of the fresh product.

The reason that dehydration during the first world war was unsuccessful was that although palatable when first dehydrated, deterioration developed, rapidly producing a product poor in flavor, odor, and appearance. Investigation was begun into factors which might aid in the maintenance of better qualities. Most of the products had had no special treatment before dehydration, nor had they been properly packaged. Treatment of foods prior to dehydration is now known to be the most important factor in controlling and preserving quality.

Methods of deterioration and spoilage are odor absorption, enzyme action and bacterial growth. The changes which take place are primarily due to the action of enzymes contained in the plant tissue. These enzymes, which are involved in the natural process of maturation, hasten deterioration. Even when such enzymes have been destroyed, slow oxidation occurs, the extent varying with the nature of the fruit. Due to the great complexity and multiple catalytic activities of the several enzymes, little is known about the actual reactions, even though the importance of their role in dehydration and storage is known. Unless the foods are thoroughly treated by some suitable methods to destroy the enzymes, they will continue to work in the dried product causing it to darken, and to change in odor, color, and in flavor. Enzymes are destroyed by heating and by some chemicals.

There are a number of methods for reducing enzymes that are practical, and which depend upon the food and chemical reaction that takes place in the particular food during dehydration, for example: sulfuring is suitable for fruits, but not for vegetables, while blanching is suitable for vegetables, but less satisfactory for fruits.

Pretreatments discussed in the literature are various methods of blanching, various dips and sulfuring.

Blanching is a canner's term applied to a brief treatment with boiling water or steam. There are several objects of the treatment: (1) to stop destructive chemical changes by destroying the agents that produce them, (2) to prevent darkening or discoloration, (3) to preserve and set the natural color, (4) to coagulate some of the soluble constituents and to accelerate the escape of moisture in drying. Blanching, whether by dipping in boiling water or exposing to live steam, must be carefully and intelligently done. It must not be confused with cooking, for it in no case takes the place of cooking in the preparation for the table. If blanching is continued for too long, it dissolves some of the valuable constituents, breaks down the pigments that give color or converts the starch into a partially cooked paste and breaks cell walls, causing poor shape.

Steam blanching consists of exposing the product to live steam for a definite period of time. This method of blanching is preferred to immersing in boiling water. Submerging in boiling water is undesirable because much of the food value is lost. From one and a half to thirty per cent of the water soluble constituents have been found to be lost by this method. Blanching alone has not proved highly successful when applied to fruits. Discoloration is retarded only slightly by partial destruction of enzymes. Fruits tend to become mushy during steaming and hard to handle.

Boiling syrup for blanching has been recommended by Eleanor Davis, Tressler, and Cruess and co-workers. Cruess comments that this method does not entirely prevent darkening but gives the product a fine flavor. However, Watts criticizes this method as protection is somewhat limited, flavor and soluble nutrients are lost during the drying period, and the treated fruit becomes sticky and difficult to handle. In this method the fruit is immersed in the boiling syrup for ten minutes, then removed from the heat and left standing in the syrup for another ten minutes.

The salt solution dip is used alone or to retain color until other pretreatments can be accomplished. When used alone as a pretreatment four to six tablespoons of salt to one gallon of water is ordinarily recommended. The time for this dip varies from ten to fifteen minutes. This is an easy and inexpensive method but is reported to be less effective in controlling changes during storage than other methods of pretreatment.

It is frequently recommended that fruits that have to be held between cutting and sulfuring or blanching be immersed in a dilute salt solution. This prevents darkening while standing, and drying of the cut surfaces which hinders sulfur dioxide absorption.

A salt sugar dip has been recommended by Richardson. No reports of the success of this treatment are available.

The addition of a little vinegar to the salt solution has also been recommended but seems to offer no advantage over plain salt solution, either in preserving color or checking enzyme action.

The most widely recommended method of pretreatment for fruits is sulfuring. In sulfuring, the fruit is exposed to the fumes produced by burning sulfur in air, sulfur dioxide being formed. The fruit is placed loosely on wooden or fabric bottom trays, these trays are placed in a sulfuring box also made of non-corroding material. Sulfur fumes corrode most metals. This box may be of heavy cardboard carton or of wood. The sides and top of the box should fit closely to prevent escape of the fumes. At the bottom of the box sufficient ventilation is provided for the burning of the sulfur. The trays are stacked two or three inches apart for free circulation of sulfur fumes. The bottom tray is ten to twelve inches from the ground or sulfuring pan, since the burning sulfur generates heat. Sulfuring should be done out of doors with sulfur sprinkled over crumbled, clean paper placed on a clean, shallow, metal pan. Care must be taken to avoid contaminating the sulfur, especially with carbon compounds, for this causes incomplete combustion of the sulfur and thus lower concentration of sulfur fumes than expected, and also causes smoking which mars the fruit. This operation must be carried out in a place where there is no danger of setting fire to grass or leaves.

The purpose of sulfuring is to preserve the natural color or to bleach, to preserve flavor, to protect in part certain nutritive values, to prevent enzyme action, molding and souring during dehydration, and to repel insects during drying and storage. It aids in reducing rehydration time and cooking time.

The variety, maturity, and general condition of the fruit determine the absorption and retention of sulfur dioxide. Delay between cutting and sulfuring is undesirable, because the surface of the fruit becomes dry, hindering absorption. Prepared fruit should not be held any longer than one and a half hours before sulfuring. Fruits blanched after sulfuring retain fifty per cent more sulfur than unblanched fruit, but blanching in either steam or hot water before sulfuring does not alter the absorption of sulfur dioxide.

Since consumers prefer a light, uniformly colored product that will not deteriorate or darken during storage, it is necessary that the fruit be sufficiently sulfured - not undersulfured. In order to keep the desired qualities it may be necessary to over-sulfur to allow for losses during handling and storage. Fruit of a high moisture content will darken in storage even though it contains a high percentage of sulfur dioxide. Sulfur fumes will not change the color of fruit that darkens after storage.

Sulfuring is complete, says Woodroof, when all browning of fruit ceases, when all red color disappears and there is a distinct tendency for the juice to ooze out of the tissues.

Authorities vary as to the amount of sulfur to use and the length of time to expose the fruit to the fumes, as may be seen in Table II.

The amount of sulfur dioxide needed to preserve the color and other qualities of the dried fruit varies with the nature of the fruit and storage conditions. According to Long and co-workers, the amount of sulfur dioxide which must be incorporated in apples to maintain quality is approximately 800 parts per million or eight one hundredths of one per cent by weight.

Sulfur treatments have been criticized as harmful to the consumer. Curtis says there is no evidence that consumers have received any injury to health from using sulfured fruit. The Farmer's Bulletin 1918 of the United States Department of Agriculture states that sulfuring is a good treatment for many fruits and if properly used is not harmful. Long and

TABLE II

Suggested Methods For Pretreatment Of Apples

Authority	Method	Time Min.	Directions
Buttrill and Ridout	1. Sulfur 2. Steam Blanch 3. Blanch and Sulfur	30 - -	1. One teaspoon dry sulfur per pound prepared fruit 2. Dip in salt solution before blanching 3. No directions given.
Caldwell	1. Sulfur 2. Sulfur Solution Dip	20-30 15-30	1. No directions given. 2. Dip in 1% solution of potassium metabisulfite or sodium bisulfite
Curtis	1. Sulfur 2. Salt Solution Dip followed by sulfuring	20-30 15	1. One teaspoon dry sulfur to one pound of fruit 2. Three tablespoons salt to two quarts of water
Cruess	1. Sulfur 2. Hot Syrup Blanch 3. Steam Blanch	60 20 5-7	1. Use one teaspoon dry sulfur per pound fruit 2. Preferably use corn syrup diluted with equal parts of water. Or use one cup corn syrup, one cup sugar and three cups water. Heat syrup to 212° F., add prepared fruit, hold at simmering point for 10 minutes. Remove from fire and let stand an additional 10 minutes. 3. Steam until each piece is heated through and is relaxed in appearance and texture.
Davis, E.	1. Sulfur 2. Sulfur Solution Dip 3. Salt Solution Dip 4. Hot Syrup Blanch	60 15 10 20	1. Use two teaspoons of dry sulfur to each pound of prepared fruit. 2. Soak fruit in a solution of three and one-half tablespoons of potassium metabisulfite or sodium sulfite per gallon water. 3. Four tablespoons salt per gallon water. 4. Same as Cruess

Suggested Methods For Pretreatment of Apples (Continued)

Duncan	1. Sulfur 2. Salt Solution Dip 3. Salt and Vinegar Solution Dip	20-30 20 -	1. One teaspoon dry sulfur to each pound of fruit 2. Three to five tablespoons salt per gallon of water 3. Two tablespoons of each per gallon of water
Eidt	1. Sulfur 2. Salt Solution Spray	30 -	1. No directions given 2. Five per cent solution
Garvin	1. Sulfur 2. Salt Solution Dip	20-30 10	1. One teaspoon dry sulfur to each pound of fruit 2. One tablespoon salt per quart of water
Neely	1. Thiocarbamate Solution 2. Salt and Vinegar Solution Dip	- 20	1. Use a five to ten per cent solution 2. Two tablespoons of each per gallon of water
Prudent & Wright	1. Sulfur 2. Sulfur Solution Dip 3. Steam Blanch 4. Salt Solution Dip	20-30 30 - 15	1. One teaspoon dry sulfur per pound of fruit 2. Immerse in solution of three ounces ($6\frac{1}{2}$ tablespoons) of sodium bisulfite or sodium nulfite to five gallons of water. 3. Steam until translucent, but firm enough to handle 4. One tablespoon salt per quart of water
Public Service Co. Northern Illinois	1. Sulfur 2. Sulfur Solution Dip 3. Salt Solution Dip	60 15 -	1. Two teaspoons sulfur per pound fruit 2. Three and one-half tablespoons of potassium metabisulfite to one gallon of water 3. Two and one-half tablespoons salt per gallon of water
Richardson-Mayfield	1. Steam Blanch 2. Salt Solution Dip 3. Salt and Sugar Solution Dip	5-7 5 5	1. Until heated through to the center 2. Six tablespoons salt per gallon of water 3. Six tablespoons salt and one cup sugar per gallon of water

Suggested Methods Fore Pretreatment of Apples (Continued)

Schroeder & Conrad	1. Sulfur 2. Salt Solution Dip 3. Blanch	30 - -	1. No directions given 2. Four teaspoons salt per gallon of water 3. Until cooked through, still holds shape
Scholy	1. Sulfur 2. Salt Solution Dip	20-30 1-2	1. One teaspoon dry sulfur to each five pounds of fruit 2. Two tablespoons salt per gallon of water
Shuey	1. Sulfur	30	1. If there is delay in sulfuring, hold in salt solution of four tablespoons per gallon of water
Tennessee Valley Association	1. Sulfur	30	1. No directions given
Woodroof	1. Sulfur	15	1. One ounce sulfur per cubic foot of space
U. S. Dept of Agriculture Farmer's Bulletin 1918	1. Sulfur 2. Salt Solution Dip 3. Steam Blanch	20-30 10 5-7	1. One teaspoon of sulfur per pound of fruit 2. Four teaspoons salt per gallon of water 3. No directions given

his co-workers state that years of scientific investigation and practical trials have not revealed another pretreatment agent equal to sulfur dioxide in preserving the desired qualities in cut dried fruits.

Sulfite dips are also used as a method of pretreatment by sulfuring. Usually a solution of about three and a half tablespoons (1.3 ounces) of sodium bisulfite, sodium sulfite or potassium metabisulfite per gallon of water is recommended. Neely recommends thiocarbamate instead of a sulfite. This, however, is not as readily available to the housewife as the sulfites, which are cheap and plentiful and, where there is a demand for them, may be obtained through local drug stores. The fruit is immersed in the solution for fifteen to thirty minutes. Caldwell says this substitute for exposure to the fumes of burning sulfur is less satisfactory since penetration into the tissues is slow, taking fifteen to thirty minutes thus permitting the diffusion of sugar and other soluble contents out of the tissues. Watts states that these dips do not penetrate cold, untreated fruit, so it is necessary to presteam for ten minutes or blanch in hot syrup for about fifteen minutes and then the fruit absorbs enough sulfur in two to five minutes. Prudent suggests the following method: Immerse the prepared fruit for thirty minutes in a solution of three ounces of sodium bisulfite or sodium sulfite to five gallons of water (0.6 ounces or one and a quarter tablespoons per gallon). This use of a more dilute solution for a longer period of time may result in better absorption of sulfur, though actual figures are not given, but there would be greater loss of soluble nutrients which would diffuse into the solution.

Methods of drying are of two types, exposure to the sun, or exposure to artificial heat. For both methods drying will depend upon the dryness of the air, its temperature and rate of circulation.

Dehydration and drying are terms often used interchangeably. The majority of laymen do not differentiate between "dried" and "dehydrated" products, the term "dried" being applied to all products from which water has been removed, regardless of the procedure. Woolrick claims that there is no line of demarcation between drying and dehydration in the language of the public.

Food technologists have attempted to establish the definition of food drying as a process in which the moisture content of the food is reduced to ten to twenty-five per cent of its original value, without specific control of temperature and humidity. Dehydration is defined as a process in which scientific control is maintained over temperature, humidity and air velocity, the water being removed under controlled conditions to a moisture content of two to eight per cent. Woolrick himself defines dehydration as, "The removal of water from food products to required low values of moisture content by a process of controlled temperature, humidity, air velocity, and enzyme action, and the resultant product to permit rehydration with a minimum loss of original natural color, flavor, odor, and nutritive value".[1]

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[1] W. R. Woolrick, The Romance and Engineering of Food Preservation Science, XCIX, (February, 1944), p. 111.

Sun drying is the least expensive method of preserving food, but the weather is not always cooperative and in various sections of the country is entirely unsatisfactory. In this method loss of food may be anticipated as well as loss of some of the characteristics of the fresh food, frequently more than is lost by other methods of dehydration. Sun drying takes much longer than artificial methods, which is one cause for food losses. Lack of sanitation, infestation by insects, inconvenience, irregularity of sunshine, and failure to retain desirable characteristics of the fresh food makes this method less desirable than others.

Artificial, or controlled heat drying, or correctly speaking, dehydration, has a number of advantages over sun drying. This process may continue day and night, clear weather or rainy, and even late in the fall when late varieties of fruits, which are more flavorful, are maturing. It permits drying to a much lower moisture content. Flavor, color, odor, texture, and food nutrients are better preserved. Keeping and cooking qualities are superior. It is a more sanitary method since the products can be protected from insects and dust.

To obtain the best dehydrated products the proper drying temperature must be used. Most products can be dried with a higher starting than finishing temperature. The purpose of the high starting temperature is to remove the moisture as quickly as possible. This high temperature cannot be used throughout the process, because as the product dries it has a tendency to discolor and char. After about three hours drying the temperature should be lowered to the finishing temperature.

Farmers Bulletin 1918 suggests that a temperature too low will cause food to sour; if too high the water filled cells may expand and burst; or the products may harden on the surface, making it more difficult to remove the remaining moisture from the inside of the food.

Eidt reports on the basis of extensive experiments that the rate of drying increases directly with the temperature, therefore to get capacity production and insure quick drying it is desirable to use as high a temperature as possible without discoloring the product. The last two hours of drying, and particularly the last hour, are the critical drying periods. He finds temperatures as high as 190° F at the beginning do not scorch, but temperatures above 165° at the end cause browning. This is corroborated by Cruess who states that most fruits withstand a high temperature, but near the end of the drying period they become quite sensitive to heat.

The "critical temperature" for any fruit is the temperature at which it is noticeably injured in an hour or two when it is nearly dry. For apples the critical temperature is 160° F. Freshly sliced apples may withstand a beginning temperature of 220° F without injury and dry very rapidly. The reason for the difference in resistance to heat injury during the first and final stages of drying is that the fruit high in moisture is cooled by the rapidity of evaporation. Near the end little moisture escapes, also the more concentrated the sugar solution and other organic substances the greater the susceptibility to heat injury or charring. Controlled dehydration experiments show that apples should be dried as quickly as possible, at a comparatively high temperature in the early stages of drying, and then the heat should be lowered as they approach dryness in order to prevent caramelization of the sugars.

TABLE III

Temperatures Recommended For Dehydration of Apples

Authority	Drying Temperature (°F) Starting	Middle	Finishing	Average Drying Time Hours
Buttrill and Ridout	Constant at 150°			12-14
Caldwell	130° gradually increase to 175°			-
Curtis	130° gradually increase to 175°			-
Cruess	165° or higher	150°	150° or less	6-24
Davis, E.	Hold between 140° and 150°			6 or longer
Duncan	140°	-	160°	6-10
Eidt	180° - 190°	175° - 180°	165°- 155°	-
Garvin	Best temperature between 125° & 140°			6-24
Neely	130°	-	-	-
Prudent and Wright	160° maximum			-
Public Service Co. N. Ill.	Constant at 150°			6-7
Richardson and Mayfield	130°	165°	145°	6-24
Schrolder and Conrad	160°	-	140°	-
Shuey	Constant at 150°			-
Scholy	160°	Reduce to 150°		-
Tennessee Valley Assoc.	150°	-	-	12-14
Woodroof	150°	-	140°	-
U. S. Dept. Agri. Bulletin 1918	130°	165°	145° 150°	-

The moisture content of fresh apples is about eighty-four per cent, after dehydration it is ten to fiften per cent, although it may be reduced commercially to one or two per cent.

In commercial dehydration determinations of the moisture content of the final product are made in the plant control laboratory by the standard vacuum-oven method or by special electrical instruments.

The homemaker is not able to actually determine the percentage of dryness of the finished product, so must depend upon qualitative tests and experience to judge the finishing point. Duncan and Woodroof describe a simple test for completeness of drying of fruits. They advise taking a handful of the product, squeezing it into a tight ball and releasing; if the fruit seems soft, mushy or wet, the moisture content is too high. It should feel firm when pressed together and spring apart quickly. It is wise, if in doubt, to leave the fruit in the drier a little longer at a lower temperature. Some of the product will dry more quickly than other parts. Toward the end of the drying, sorting should be done and pieces sufficiently dry removed, leaving the rest to continue until all is uniformly dry.

Woodroof obtained an average yield from forty-eight pounds (one bushel) of fresh apples, which gives twenty-four pounds of prepared fruit, 4.3 pounds of the dried product. Shuey reports yields of from 4.5 to five pounds of dried apples from fifty pounds of apples as purchased, the prepared weight being thirty pounds. According to Caldwell, drying reduces the fresh product to between one-fourth and one-ninth of its original weight.

Within the last two or three years protective packaging has become a fundamental problem in food preservation. It has long been recognized that infestation by insects and attack by rodents is a problem of storage. More recently the extent to which nutrients, flavor, odor, and color are affected by storage conditions has been realized. It is most important that the qualities above mentioned be maintained during storage. The aim of modern storage is to preserve these qualities to the highest possible degree as well as to protect the product from insects, rodents and bacterial contamination.

Mrak suggests protective packaging, or cold storage, to check chemical changes which result in "off flavors" and odors and in discoloration, as well as a decrease in certain vitamins. The following facts are summarized by Buttrill and verified by many others. Containers should be: (1) moisture proof, (2) air proof, (3) odorless, (4) tasteless, (5) insect proof, (6) sturdy and puncture proof, (7) economical, (8) practical in size, (9) convenient to fill and seal. The problem of packaging comprises: (1) the amount and type of protection required, (2) selection of material to meet these requirements, (3) and for commercial production provision of mechanical means of filling, sealing, labeling, and packaging.

For home use containers such as fruit jars and certain types of bags which are heat sealed are satisfactory. Tightly closed metal or glass containers are the only types that provide absolute protection for a period of months. Glass has the disadvantage of not protecting from light. Cellophane or heavy paraffined paper bags are good if they are kept from cracking and tearing. The numerous bags being tested are economical, light and easily handled, although rodents and certain insects may penetrate them. These bags should be small, holding not more than enough for one or two meals. They should be placed in boxes or tins away from light, moisture, air and rodents, and kept in a dry place.

Packaged foods should be examined often. Mold, insects and mice seldom begin in more than one or two places at a time, but after entering will spread quickly. If damaged particles are found it is best to separate the damaged from the good, and discard it, rather than to fumigate or use other chemicals. Products questionable in respect to moisture content may be returned to the dehydrator and heated at 160 degrees for a few minutes. Improperly dried foods undergo chemical deterioration more quickly than well-dried products. Microbiological deteriorations which occur in dried fruits containing as little as eighteen per cent moisture can be retarded by more complete drying and storage at a cold temperature.

The "life" of fruits prepared at home cannot be counted on for more than nine to twelve months. When first dehydrated the color, texture, and flavor is very satisfactory, may even be superior to the same products canned, but a gradual change in color, flavor and odor takes place, and in some cases foreign flavors develop.

Future scientific knowledge of storage methods for dehydrated products may enable dehydration to compete successfully with the new popular method of preserving by freezing.

The preliminary soaking of dried foods before cooking is termed "rehydration", "refreshing" or "refreshening". The proportion of water and length of time for best results does not yet seem to have been established, judging from the diversity of opinion in the literature.

Rehydrated products should have a color, flavor, and texture comparing favorably with that of the fresh food. These qualities obviously depend upon the quality of the original fruit, its maintenance throughout the dehydration process and subsequent storage, as well as upon the rehydration procedures. Many commercially dehydrated products are accompanied by directions for refreshing. In general instructions are merely to add enough water to permit "plumping" and allow for cooking.

Stillman, Watts and Morgan found in a study on palatability of dehydrated vegetables the following results: (1) from a palatability standpoint the blanching could be done either by steam or by boiling briefly in water, but steam blanching is preferred because it increases retention of soluble nutrients, (2) most vegetables tested improved somewhat in palatability, when they were soaked before cooking, (3) the soaking time usually ranged from one to three hours. It is doubtful whether the slight increases in palatability were great enough to balance the probable losses in soluble nutrients during soaking periods of several hours unless the soaking water is used, (4) vegetables should be covered with water during the entire soaking period, (5) comparison of canned with dehydrated samples of peas, snap beans, and spinach, all dehydrated samples were superior to the canned.

The most extensive study of rehydration has been reported by Woodroof, who claims that soaking in hot water is the quickest and best way to rehydrate the product, since this results in better color, flavor and texture than other methods. He ran tests on twenty-four lots of apples and other fruits using water ranging in temperature from seventy-five degrees Fahrenheit to almost boiling. About 300 weighings were made to determine the rate of absorption of water. The most rapid rehydration was found when water was held at 165° F, but the difference in rate at various temperatures was not very great. In all cases rehydration was most rapid during the first fifteen minutes. During this time the apples more than doubled in weight, and in two hours rehydration had reached its maximum. During rehydration dried fruits absorb from fifty to seventy-five per cent of the water lost in dehydration, and continue to take up more during cooking, although they never regain all the water lost.

Temperature of soaking is not specified by other investigators.

The general direction for rehydration, "add enough water to cover", ranges from a proportion of one part apples to one and a half or two parts water, to one part apples and six parts of water. It is difficult to give specific directions since the amount of water removed in drying, the rate of cooking, and the amount of agitation affects the amount of water needed. Experience is the best guide for the amount of water to use. It is emphasized that water used for rehydration be used for cooking to save food values.

The length of time for soaking claims as many variations as the amount of water to add. However, the following points are clearly brought out in the literature: (1) too long soaking draws out flavor, for apples keep soaking time short, (2) thinly sliced apples need no soaking.

The time required for cooking is reported to depend upon the completeness of refreshing, and also on the kind of utensil used, the amount of food cooked, and the amount of heat used. Again, only a general rule is given: Cook slowly until tender, longer cooking results in loss of flavor and texture.

The conclusion to be drawn from the literature as to the best procedure for the preparation of the dehydrated apples is: Rehydrate rapidly in just enough water to cover and cook slowly until tender, the cooking time depending on the length of the preliminary soaking.

The preparation of appetizing food necessitates a knowledge of what constitutes a desirable food and why foods are either good or poor. Every consumer has his own standard for such foods, thus making it difficult to set up a standard for judging foods on a wide basis. One of the biggest problems involved in food flavor studies is an accurate measuring of the flavor of the finished product in such a way that the results can be interpreted by others. The sight of food automatically results in a judgment of it, and this first superficial judgment is apt to influence the assessment of other qualities. Judging with a score card demands a thorough and critical examination with a definite record of the judgment.

There are many varieties of score cards, but there are so many as yet uncontrolled factors which enter into the testing and scoring of flavors, that none satisfactorily estimates the individual taste. However this inadequate subjective method, which depends on human senses and on the setting up of a score card that the judges can follow, is still the only technique for measuring the palatability of foods.

In ordinary food the flavor is a mixture of true taste and odors accompanied by many sensitivities, such as the strong feeling of coolness in the mouth and nose caused by peppermint; the pungency of pepper and other spices is a part of their flavor; the smoothness or graininess of some foods as chocolate or peanut butter and the oiliness of oils are largely feeling, and these reactions to the mouth and nose must be given consideration. The part which odor plays in the desirability of foods is well known, the appetizing odor of roasting meat, for example, definitely adds to its palatability. According to Watts the most important component of flavor is smell. Little is known of the sense reaction to odors, but Crocker and Henderson have suggested a classification of four fundamental odors: fragrant, acid, burnt, and caprylic. The true tastes are sour, salty, sweet and bitter, each has its own sensory end organs and its own chemical stimuli.

In a study of bread flavor undertaken by the United States Department of Agriculture Bread Flavor Committee, it was found that small differences could not be accurately determined by a group of ninety-six judges, and that comparatively few of the group could duplicate their judgment. Therefore Dr. King, a member of the committee, conducted an investigation on the selection of judges with greater acuity of taste and smell and more consistent judgment. Those subject to head colds or disliking the food to be tested were eliminated and the remaining sixty-four persons tested for their sensitivity to duplicate solutions of varying concentration of sodium chloride, sucrose, lactic acid and caffeine, representing the four primary tastes. Although there were no cases of taste blindness, there were great variations in sensitivity to flavor and many cases of indiscrimination, especially for salt and sour. A panel of fourteen was chosen by elimination of the least discriminating and consistent. Parallel tests were made with this panel and the entire group of sixty-four. It was found that no significant difference in final results was obtained by using the selected panel rather than the whole group. However, the judges in the panel were more consistent in their scoring and duplicated their own results more frequently.

Fabin and Blum made extensive experiments on taste sensitivity and on the compensatory or competitive action of the three basic flavors, saltiness, sourness, and sweetness. Solutions of various sugars, salts, and acids were used for testing. Using judges with little or no previous experience they found only fifteen out of twenty-five who were sufficiently accurate and consistent to be reliable. Of these fifteen only ten were suitable for general tasting tests, the others being very sensitive to some one or other of the three basic flavors. They found that sugars reduced the saltiness of sodium chloride, and also, to varying degrees, the sourness of acids; that acids increased the saltiness of sodium chloride, and either increased or had no effect on the sweetness of sugars except fructose, in which the sweetness was reduced; that salt reduced the sourness of acids and increased the sweetness of sugar. These results may find useful application in the flavoring of foods.

Palatability studies of commercially dehydrated vegetables were done by Fenton and Gifft at Cornell University. No information was given about the number or choice of judges, but definite conclusions were drawn on the basis of their ratings of odor, flavor, and texture by descriptive terms such as natural, good, weak, bad, hay-like, etc. No definite scale of terms or set of score values was provided. Judgment was to be made on the merit of the product to be scored, not on a comparative basis.

Batchelder, using a panel of five selected judges, found satisfactory results were obtained when home dehydrated vegetables were judged for appearance, odor, flavor, consistency and acceptability, the judging terms being, (1) excellent--quality equal to the best fresh,

(2) good--satisfactory, (3) fair--below average, but not objectionable, (4) poor--objectionable but edible, (5) very poor--inedible. No numerical scores were assigned.

In palatability studies of home dehydrated vegetables Stillman, Watts and Morgan used twenty judges selected at random, gave no information about the product and asked that it be rated as to desirability of flavor, texture and color. Numerical weights were assigned to the descriptive words so that a composite palatability score could be obtained. Both flavor and texture were assigned twice the weight alloted color. This appears to have been a satisfactory method, as definite conclusions could be drawn from the results.

Nason summarizes suggestions which are useful in planning palatability studies and which are, briefly:

The method of preparation of the samples to be tested should be known in such terms that it can be repeated successfully.

There should be but one possible cause for the effect being studied, that is, only one thing should be varied in each test.

The number of samples used should be small.

Samples should be lettered or numbered, not labelled, for identity.

The judges should be well informed as to the method of scoring before beginning.

The mechanics of scoring should be clear and simple.

Prejudice among the judges must be eliminated as far as possible.

Blindfolding the judges is sometimes advantageous.

The easiest way to select consistent judges is to give identical samples to detect inaccuracies.

Choose a number of judges suitable for the purpose in hand. A large number of unselected judges may be preferable for consumer studies and a small number of carefully selected judges for more accurate experimental studies.

Consider locality, occupation, age, religion, perhaps sex, psychological association, and time and place of giving test, since preferences are partly determined by these factors.

From the review of the literature it would appear that factors which may affect the palatability of dehydrated apples and about which least is known are methods of pretreatment, methods of refreshing and cooking, and methods of storing. Time limitations have made adequate investigation of storage impossible but an investigation of pretreatment techniques and of various methods of preparation for the table has been made.

CHAPTER III

EXPERIMENTAL PROCEDURE

Hand-picked Stayman Winesaps, from North Carolina, were bought from the open market for the experiment. This variety was selected because it is among those recommended as most suitable for dehydration and was also the best quality apple available at the season (mid-October). Two bushels, gross weight one hundred pounds, net weight ninety-one pounds, carefully selected as to size, freedom from blemishes and stage of maturity were obtained from the same orchard. The apples averaged three and one-half inches in diameter and seven ounces in weight. The dehydration procedures were completed within two weeks of purchase. The fresh apples remaining were stored in a refrigerator at 40° F for later use in comparative cooking tests.

Six pounds was found to be a practical and easily handled amount to work with at one time. With larger amounts there is delay between the steps of preparation while smaller lots make the work less efficient. Rapid work is essential to prevent darkening, and lots of this size can be prepared within twenty minutes.

The equipment required in the preparation, dehydration, cooking, and testing, excepting the sulfuring box and the electric dehydrator, is regular household equipment. Following is a list of the utensils used.

For preparation and pretreatment:

- Set of kitchen scales
- Stainless steel paring knife
- Apple corer
- Large stainless steel knife for slicing
- Wooden board
- Pan—two gallon capacity

One quart measure

Measuring spoons

Long handled spoon

Long handled fork

Pressure cooker with fitted rack and lid

Wire basket

Tea towels

For Storage:

One and two quart glass jars with tight fitting tops

Cardboard carton for storing the filled glass jars

For Cooking:

Pyrex sauce pans

Wire sieve

Serving dishes and spoons

The sulfuring box was made from a heavy carton seventeen inches high, nineteen inches wide and twenty-two inches deep. Narrow strips of wood were tacked onto the sides to hold slatted trays, the lowest being ten inches from the ground and there being two and one-half inches between trays. The lid opened from the ground up with a slit one inch high and six inches long cut in the lower edge to allow air to enter for the burning of the sulfur.

A Top Line Home Dehydrator, Model 200, approved by the War Production Board and the Department of Agriculture was used. This cabinet is made of plywood, interlined with non-combustible "Stonewall" and has a "Leak-tite" door seal. The outside dimensions are: thirty-seven inches high, twenty-five inches deep and twenty inches wide. On the back of the cabinet is a damper five inches wide and six inches long, placed three inches below the top, which is for humidity control. The cabinet contains a heating unit placed at the bottom and above it seven removable trays, each seventeen and three-fourths inches long and twelve inches wide; all the trays are made of wood, two with wood slats and the other five of wire screen. This gives a capacity for drying fifteen to twenty pounds of food at a time. The heating unit is composed of an electric heating coil, controlled by a thermostat with a temperature range of 140° F to 170° F, a fan for air circulation and a 150-watt lamp which is not operated by the thermostat but burns continually while the dehydrator is in use and serves to balance the heat in the cabinet. The entire electric circuit is controlled by a switch located on the front panel of the cabinet. This unit is designed for use with a current of 110 volts, A. C. only.

The six pound lots of apples were weighed, washed, peeled, cored, weighed again, and sliced into one-eighth inch rings. As soon as prepared they were treated by one of the following methods.

LOT I. The sliced apples were arranged, overlapping in single layers, on the wooden sulfuring trays and placed immediately in the sulfuring box, which was set up outdoors on a cement walk. One teaspoon of sulfur per pound of prepared fruit was sprinkled on a piece of crumpled paper and placed on a shallow, clean, tin lid at the center of the bottom of the box. The paper was lighted, the box closed and the fruit left for thirty minutes, after which it was immediately placed in the dehydrator.

LOT II. A salt solution of four tablespoons per gallon of water was prepared before peeling the apples. The apples were dropped into the salt solution as peeled, removed one at a time for coring and immediately returned. When all had been cored they were drained, dried with a clean dish towel and weighed. They were then sliced into the salt solution and as soon as slicing was complete the fruit was removed from the solution, the pieces that had been in longest being removed first, the trays loaded and at once placed in the dehydrator.

LOT III. For steam blanching a pressure cooker with a rack to hold the food above the level of the boiling water, was found convenient, though any kettle with a tight fitting lid could be adapted for use. Heating was begun before the apples were prepared, so that the water would be boiling briskly when the apples were ready. After slicing, the apples were placed in a wire basket, lowered to the rack in the pressure cooker, the lid placed on but not clamped, with the pet cock open and steaming continued for seven minutes. The prepared apples were divided into two lots for steaming as the wire basket was too tightly packed to permit circulation of the steam and even heating throughout if all were done at one time. After blanching they were transferred to the trays with a fork and placed in the dehydrator.

LOT IV. A preliminary steam blanching, carried out as described for Lot III but limited to the time required for the fruit to become translucent (five minutes) was followed by sulfuring as described for Lot I.

LOT V. Blanching was carried out by the method used for Lot III except that steaming was continued only until the slices became translucent, which was four minutes. Smaller amounts were steamed at a time, this lot was divided into three parts instead of two to insure more even heating.

LOT VI. Corn syrup was diluted with equal parts of water, as recommended by Cruess, and heated to the boiling point. The apple slices were suspended in a wire basket in the boiling syrup for ten minutes, the kettle then removed from the fire and the apples allowed to stand in the hot syrup for an additional ten minutes, then drained and placed on the trays for dehydration. As in steaming, the fruit was divided into two lots to insure uniform contact with the syrup.

LOT VII. A solution of four tablespoons of salt and one cup of sugar per gallon of water (Richardson's suggestion) was prepared before peeling the apples. The same procedure was then followed as with Lot II.

LOT VIII. A sodium bisulfite solution was made with three and one half tablespoons of sodium bisulfite per gallon of water. The apples were immersed after all had been peeled and cored and allowed to stand fifteen minutes. During this time they were removed individually for slicing, the slices being returned to the solution as cut. In all cases the trays (area one and one tenth square feet) were loaded with about one and a half pounds of prepared fruit, the last tray usually having a smaller amount. The rings were overlapped but not crowded.

It was found in preliminary tests with the dehydrator that the temperature could not actually be raised to the highest level claimed, 170° F, seldom reaching more than 150° F with no load in the cabinet. This was partly due to poor insulation and ineffectiveness of the "Leak-tite" door seal. The situation was somewhat improved by covering the cabinet with layers of blanket. The cabinet was preheated, with the damper closed. When the apples were ready the thermometer was read, the dehydrator was loaded as quickly as possible to conserve heat, the trays being staggered alternately to form a channel for circulation of the air. After one hour the trays were reversed to provide more rapid and uniform drying and the fruit turned to avoid sticking. At this time the damper was opened slightly, enough to feel moisture on the back of the hand. At the end of the third and sixth hours the thermometer was read, the trays reversed and the rings turned if necessary. At the sixth hour while changing trays, tests were made for completely dried rings, and any found were removed. For the remaining drying time the damper was opened slightly more and left thus until the end of the drying period, which ranged from eight to eleven hours.

After completing the dehydration procedures cooking tests were carried out on the products. Tests were planned, as far as possible, to give results through which to build for the following test, but class schedules sometimes made the most desirable sequence impossible. For example, the rate and length of time for cooking as found from the results of Test II were used throughout the rest of the experiments.

In preliminary studies tests had been made of different periods of rehydration and methods of cooking and their effect on the flavor of the cooked dried apples. The results were obtained from judging by a group of five experimental food class members. The times of soaking studied ranged from no soaking to seven hours. The apples soaked seven hours, which were poor in flavor compared to those soaked a shorter time, were discarded as undesirable. No difference could be observed between the flavor of those with no soaking up to two hours soaking. A ratio of six to one of water and apples by weight was found to be sufficient to just cover the apples and to allow "plumping" and cooking to make an apple sauce of good consistency. The rate of cooking was also tested. These judges preferred the gentle boil, (bubbles rise continually and break on the surface) to simmering, (a temperature of about 185°, bubbles form slowly and break below the surface of the water). Even though the above tests have their limitations they gave a basis from which to begin the cooking tests that follow.

TEST I. Introductory Test

Fresh apple sauce was made from the same lot of apples used for dehydration, kept at 40° Fahrenheit. A standard recipe used by the Sophomore Foods Class and taken from Sutherland's Foods Laboratory Manual was used for fresh apple sauce:

1 pound apples (approx. 4)
1/2 cup water
1/4 cup sugar

This recipe was doubled to make sufficient amount for four samples, and cooked in two lots, each for fifteen minutes. The first lot was put through a sieve, salted to taste, (less than one-eighth teaspoon) returned to the flame and heated until the salt was dissolved. One half of this sample was left thus; to the other half of this lot one-eighth of a cup of sugar was added and the sauce heated until the sugar dissolved. The second lot was likewise pressed through the sieve and equally divided; to one half was added one-eighth cup of sugar as above, the other portion was left plain. All samples were cooled to room temperature for serving.

TEST II. The Rate of Cooking

Two lots of eighty grams each were weighed out from both the dried apples pretreated by sulfuring and those pretreated by blanching. This weight was estimated to be enough to serve all the judges and corresponds roughly to one cup, or a little more, of dried apples. Four hundred and eighty grams of hot water were added, which was just enough to cover and represented a proportion of six of water to one of apples by weight. These samples were immediately brought to a boil and one lot of each cooked at a simmering temperature and the other two samples at a gentle boil. In twenty minutes each sample was tender enough to press through the sieve easily.

TEST III. Influence of Time of Soaking in Cold Water

Since long soaking was eliminated by preliminary tests only periods two hours or less were tested. Four lots of sulfured apples, sixty grams each, were placed in individual sauce pans. To each lot 360 grams of cold water, (just enough to cover) was added. The lots, designated A, B, C and D, were soaked for two hours, one hour, half an hour and not at all, respectively. At intervals estimates of the progress of refreshing were made by draining the apples in a sieve and weighing both apples and water, which were then returned to the same container. Great care was taken to avoid loss of water during this step. The results appear in Table VI. All were cooked for twenty minutes at a gentle boil, and both apples and water weighed before straining. As in all the cooking tests, the cooking water was used with the pulp in preparing the apple sauce.

TEST IV. Effect of Storage

One sample of apples pretreated by salt solution dip followed by steam blanching, and another pretreated by salt solution dip only, which had been prepared the previous spring season, were stored at room temperature for eight months. Compared with the above samples were apples similarily pretreated but with only two weeks storage. To eighty grams of each sample 480 grams of water was added and they were cooked twenty minutes at a gentle boil as described in experiment II.

TEST V. Influence of Time of Soaking in Hot Water

This test was carried out with sulfured apples as test III except that eighty gram lots were soaked in 480 grams of boiling water. The weights were recorded during refreshing and after cooking and appear in Table VI.

TEST VI. Effects of Various Methods of Steam Blanching

Sample A was pretreated by steam blanching seven minutes (Lot III), B steam blanched five minutes and sulfured, (Lot IV), and C steam blanched four minutes, (Lot V). Eighty grams of each sample were placed in sauce pans, 480 grams of cold water added and soaked for one hour before cooking. The apples and water were weighed as in experiments III and V but at fifteen minute intervals during the hour.

TEST VII. Effect of Pretreatments

Forty-five grams of each of the following lots were soaked in 270 grams of water for thirty minutes and cooked and prepared for serving as in other tests:

A - Lot I pretreated with sulfur

B - Lot II pretreated with salt solution dip

C - Lot V pretreated with steam blanching four minutes

D - Lot VII pretreated with salt and sugar solution dip

E - Lot VIII pretreated with sodium bisulfite

F - Lot IX pretreated with hot syrup blanch

G - Lot X pretreated with salt solution dip and blanching

H - fresh apples prepared by the standard recipe given in Test I without adding sugar

TEST VIII. Comparison of Fresh, Frozen, Canned and Dried Apples

The following samples of apples were compared:

A - Lot V pretreated by steam blanching four minutes

B - Lot VIII pretreated with sodium bisulfite dip

C - sun dried apples from the local market at 36¢ per pound

D - Canned apple sauce. Musselanian's fancy quality, sugar and water added. Cost 19¢ per number two can (one pound, four ounces).

E - fresh apples prepared by standard recipe, (Test I), with sugar

F - frozen apple sauce. Birdseye Brand, cost 27¢ per pound.

G - fresh apple sauce prepared by standard recipe but sugar not added

The dried apples A, B and C, were soaked thirty minutes in cold water, six parts by weight to one of apples, cooked twenty minutes at a gentle boil, strained, and cooled to room temperature. All the samples, A through G, were served at the same time.

TEST IX. Comparison of Soaking in Hot and Cold Water

Sixty gram lots of apples pretreated by sodium bisulfite dip were soaked in six parts of water to one of apples be weight, as follows:

Sample A cold water for two hours

Sample B cold water for thirty minutes

Sample C no soaking, cold water poured over apples and cooked immediately.

Sample D boiling water for two hours

Sample E boiling water for thirty minutes

Sample F no soaking, boiling water poured over apples which were cooked immediately

All samples were cooked twenty minutes at a gentle boil.

TEST X. Influence of Added Flavoring On Palatability

One hundred and eighty grams of apples treated by salt solution dip, one of the poorer flavors, were soaked in 1080 grams of water for thirty minutes, then cooked and prepared for serving as previous samples. This lot of apple sauce was divided into three samples of one cup each. One teaspoon of lemon juice was added to one, one-eighth teaspoon of cinnamon added to a second and nothing was added to the third. These were compared with fresh apple sauce seasoned in the same manner.

The cooked products were presented for tasting tests as soon as possible after preparation. All were at room temperature and were served in identical glass dessert dishes arranged attractively on a table or tray, the various samples being identified by letters.

A score card, developed from information in the literature on palatability and on scoring food flavors, was used for rating. A sample of this score card appears on the next page. The score card gave a double check, first by giving a numerical rating to each sample according to the descriptive terms excellent, good, fair, poor, unacceptable, and second, by selection of the most and least desirable samples. Double weight was given the values for flavor, the most important factor studied, in accordance with the practice of Stillman, Watts and Morgan.

SCORE CARD

Number ____________
Date ____________

Score Values

Excellent 3
Good. 2
Fair. 1
Poor. 0
Unacceptable. . . . . . .-3

Suggestions for Remarks

<u>Color</u>: Natural, too dark, too light

<u>Odor</u>: Natural, "off odor"

Flavor: Pleasing, strong, tasteless, too sweet, too sour

Sample	Color	Odor	Flavor	Remarks	

1. Which sample do you like best:

2. Which sample do you like least:

The judges consisted of three groups, I, the sophomore foods class, composed of thirty-seven members, selected as inexperienced in scoring food flavors; II, the demonstration class, made up of twelve juniors and seniors, representing a group with some experience in evaluating and scoring foods; III, a group of seven members of the home economics food's staff representing experienced judges. These were selected as judges so that a regular uniform group, which could be depended upon and which could be instructed as necessary, would be available at a definite time and place so that the test could be carried out in as systematic a manner as possible.

Before the first test the judges were called together, given a score card and each item on the card noted and discussed. These judges were asked to score all samples of apple sauce served as fairly as possible, without being limited by their own prejudices or likes and dislikes, and to avoid discussion with other judges. No information was given about the apple sauce. As small a number of samples as possible was used, never less than three, nor more than eight.

CHAPTER IV

RESULTS AND DISCUSSIONS

The pretreatments used in these experiments were all suggested in the literature as practical methods for home dehydration. It was found that the easiest and quickest were the salt solution dip, the salt and sugar solution dip and the sodium bisulfite dip, which required similar techniques.

Sulfuring is not difficult to do, but requires more time than the above pretreatments. The preparation of the sulfuring box, the thirty minutes sulfuring and the changing of fruit from sulfuring trays to dehydrator trays if they are not of the same dimensions, require extra time and the weather may interfere with the outdoor sulfuring process.

Steam blanching is the hardest pretreatment to do. It requires more equipment and more handling of the fruit, it is difficult to obtain even penetration of the steam through the fruit, more experience is needed to determine the right steaming time, and working with steam, especially in warm weather, is inconvenient and uncomfortable. A difference of only one or two minutes in steaming time causes a great change in the consistency of the apples. If over steamed they are too soft to hold their shape. To steam until translucent is a better rule to follow than a prescribed number of minutes. At this stage the apples are ready for dehydration and the time required to reach it varies for different samples of even the same product. For example, two different lots of these apples required five and four minutes respectively to reach the translucent stage. When steam blanching is followed by sulfuring the procedure becomes longer and more complicated, as actually the work of two methods of pretreatment is done. Transferring the hot blanched product to the sulfuring trays is difficult, and another transfer has to be made to the dehydrator trays. From the point of view of economy of time and effort this is the least desirable method. Immersing in salt solution before steaming adds a step to the process, but prevents darkening.

Blanching in hot syrup requires the same equipment and handling of the fruit as steam blanching, but even blanching is more easily obtained in syrup than in steam. The cost is greater and more time is consumed, for the syrup must be prepared and the blanching continues for a longer time. However, it is an easier and faster method than steaming followed by sulfuring. When done exactly as described by Cruess, the apples were over cooked. Ten minutes at the simmering temperature was sufficient to produce translucence.

The time required for dehydration varied from seven to eleven hours as may be seen in Table IV. The inefficiency of the dehydrator prevented any accurate study of dehydration time, however. No relation between the weather and time could be observed. The load in the dehydrator had some effect, as when two lots, numbers III and IV, totaling about eight pounds fresh weight, were run at the same time, from ten to eleven hours were required. However, one four pound lot sulfured, and some of those treated with salt and sugar dip, also required ten hours. Sulfuring is said to reduce the time required, but did not do so in this series of experiments. It was found necessary, contrary to reports in the literature on the use of forced draft dehydrators such as this, to rotate the position of the trays and turn the pieces of fruit to obtain even drying. More difficulty was experienced with the syrup blanched apples than with others.

For the ten lots here reported the over all as purchased weight

TABLE IV

Yield and Characteristics Of Dehydrated Apples

Six Pound Lots A. P. Dehydrated at 145° F

Lot	Pretreatments	Weight Fresh	E. P. Dry	Drying Time	Color	Odor	Texture
		pounds	ounces	hours			
I	Sulfuring	4	12	10	Creamy white	Natural apple	Hard
II	Salt Solution Dip	4 1/2	12	7-8	Deep cream with touch of pink	Cider hay-like	Pliable
III	Steam Blanching 7 minutes	4 1/2	12	11	Dark brown, edges lighter	Cider	Velvety, Pliable
IV	Steam Blanching 5 min. & sulfuring	4	11	10	Brown, uneven, gray streaked	Sulfur	Velvety, springy cushioned feel
V	Steam Blanching 4 minutes	4 1/2	12	7 1/2-8	Brown uneven	Cider	Pliable
VI	Blanching in Syrup 20 minutes	4 3/8	14	10	Light tan uneven	Slight cider with syrup	Gummy, Candied
VII	Salt and Sugar Solution Dip	4 1/4	10	9 1/2-10	Cream with tinge of pink	Cider	Pliable
VIII	Sodium Bisulfite Dip	4 1/4	10	9	Light cream yellow cast	Mild apple and sulfur	Springy, Pliable
IX	Blanching in Syrup 10 minutes	2 1/3*	9	9	Light tan uneven	Cider with syrup, haylike	Candied
X	Salt Solution Dip and Steam Blanching 5 min.	4 3/4	11	8	Light cream	Fresh mild cider	Springy, Pliable

* Used only 3 pounds A. P.

TABLE IV

...cteristics Of Dehydrated Apples

...s A. P. Dehydrated at 145° F

...r	Texture	General Appearance and Remarks	Lot
...ural apple	Hard	Attractive in color and shape.	I
...er hay- ...e	Pliable	Fairly attractive, rings held shape but shrivelled. Color a little dark. Dried unevenly.	II
...er	Velvety, Pliable	Unattractive. Held shape. Color very poor. Long drying period due to double load in dehydrator.	III
...fur	Velvety, springy cushioned feel	Most unattractive. Rings held shape but shrivelled. Color very poor. Dehydrated with Lot III.	IV
...er	Pliable	Rings broken. Unattractive in color and shape.	V
...ght cider ...h syrup	Gummy, Candied	Rings misshapen and broken. Color unattractive.	VI
...er	Pliable	Fairly attractive in color and shape though somewhat shrivelled. Dried unevenly.	VII
...d apple ... sulfur	Springy, Pliable	Attractive, well shaped, plump rings.	VIII
...er with ...up, ...like	Candied	Shape much better than Lot VI. Rings easier to handle during dehydration.	IX
...sh mild cider	Springy, Pliable	More attractive in color and shape than other blanched lots.	X

equaled fifty-seven pounds, which yielded forty-one and one half pounds edible portion and seven pounds of dehydrated apples. This represents a yield per bushel (46 pounds) of thirty-six pounds edible portion and five and a half pounds of dried apples, or a reduction to about one-eighth of the original weight. This is a higher final yield than reported by Woodroof, Shuey or Caldwell due to the fact that good quality and careful preparation decreased waste and gave a larger proportion of edible portion per bushel. Hand peeling and home preparation methods may be more economical than commercial procedures.

The method of pretreatment has some affect on the weight of the yield. When the weight of the dried apples was calculated as the per cent of the fresh edible portion the yield varied from twenty-four to fourteen per cent. The twenty minute hot syrup blanch gave the highest yield, twenty-four per cent; when continued for only ten minutes, the yield was twenty per cent. This apparently high yield was due to the weight of the sugar which had been taken up by the apples. The lowest yield, fourteen per cent, which meant the most complete drying, was given by the salt dolution dip followed by steam blanching. The other methods of pretreatment gave yields of about eighteen per cent.

As far as color and general attractiveness in appearance are concerned, (Table IV), the sodium bisulfite dip, the sulfured, and the salt solution dip followed by steam blanching, were the best. The color of the sodium bisulfite dip was a light cream with a yellow cast, the sulfured rings were a creamy white, the salt solution dip followed by steam blanching gave a deep cream with a tinge of pink. The salt solution dip and the salt and sugar solution dip were a little darker than any of the above group and a little more shrivelled. The blanching in hot syrup gave a product very uneven in color but not unpalatable looking. The steam blanching and sulfuring were the most unattractive in appearance. All other lots held their shape better than those steamed and hot syrup blanched.

The results of the ten cooking and tasting tests are summarized in Table V. The average score calculated from the total score given by each group, the total number of points scored by all the groups combined, the order of preference of the samples in each test as determined by the number of times they were chosen the best and the least desirable, and the total number of times each sample was placed in these two categories, is included. The number of judges varied somewhat due to absences, and for Test III and VII the Demonstration Class (Group II) was unavailable.

TEST I. This test was made to try out the score card and acquaint the judges with its use and to determine how important the addition of sugar and salt might be in affecting flavor preferences. The score card appeared to be satisfactory in the hands of all groups and the results obtained by its use were clear cut. It was therefore deemed satisfactory for continued use. The inexperienced judges tended to consider texture as well as the points which they were asked to note. Salt, at least in this amount, which was the smallest that could be measured accurately, was rated undesirable by both score value and choice. When sugar as well as salt was added, the apple sauce was considered less objectionable by the students, but worse by the staff. When salt was not added, Groups I and II, the inexperienced and experienced students, preferred sweetened apple sauce to plain, but Group III, the staff, preferred plain apple sauce. Although by a small margin when scores were considered, plain apple sauce was picked out as

TABLE V

Results of Tasting Tests

Test Number	Sample	Number of Judges	Average Scores of Groups I	II	III	Total Score	Group Order of Choice I	II	III	Times Chosen Best	Worst
I	Fresh, plain	55	7.8	6.1	8.2	424	2	3	1	18	19
	Fresh, with salt		5.9	6.6	6.0	342	4	4	2	2	15
	Fresh, with sugar		8.8	9.4	8.1	499	1	1	2	25	1
	Fresh, with salt and sugar		6.0	7.9	4.7	351	3	2	2	10	20
II	Dried, sulfured, simmered	56	6.0	6.2	8.4	359	1	1	1	23	13
	Dried, sulfured, boiled		6.7	6.1	7.2	374	2	2	4	18	6
	Dried, blanched, simmered		3.1	2.1	2.2	156	3	4	1	7	24
	Dried, blanched, boiled		4.7	6.0	3.4	270	4	2	1	7	13
III	Soaked 2 hrs. cold	43	4.6		7.5	220	4		2	9	10
	Soaked 1 hr. "		7.3		7.5	317	1		2	9	14
	Soaked ½ hr. "		4.9		8.2	237	3		1	10	6
	Not soaked		7.3		7.0	313	1		4	15	13
IV	Stored salt dip	55	2.2	2.5	4.8	144	3	3	2	7	9
	New salt blanch		5.8	5.9	6.2	318	1	1	1	34	1
	Stored salt blanch		0.6	0	3.0	32	4	4	4	1	36
	New salt dip		3.3	3.9	4.7	195	2	1	3	12	9

Results of Tasting Tests (Continued)

Test Number	Sample	Number of Judges	Average Scores of Groups I	II	III	Total Score	Group Order of Choice I	II	III	Times Chosen Best	Worst
V	Soaked 2 hrs. hot	48	8.4	7.3	7.0	387	1	3	2	15	10
	Soaked 1 hr. "		8.7	7.8	8.5	409	2	1	4	16	5
	Soaked ½ hr. "		8.1	7.9	9.2	393	3	2	1	11	5
	Not soaked		6.7	6.5	9.0	329	4	4	2	5	28
VI	Blanched 7 min.	49	4.2	7.7	6.6	257	2	1	2	13	5
	Blanched 5 min. and sulfured		2.0	0.5	3.6	80	2	3	2	4	39
	Blanched 4 min.		6.0	4.8	6.8	289	1	2	1	32	5
VII	Sulfured	38	5.8		6.6	226	2		2	8	3
	Salt solution		1.7		6.5	95	7		5	0	14
	Steam blanch		3.6		6.6	156	5		2	3	1
	Salt and sugar		3.0		7.0	141	7		5	0	3
	Bisulfite		8.1		9.3	317	1		1	19	0
	Syrup blanch		6.2		7.2	245	3		5	3	2
	Salt and blanch		4.2		6.8	176	6		2	2	3
	Fresh		4.9		5.1	189	3		5	3	12

Results of Tasting Test (Continued)

Test Number	Sample	Number of Judges	Average Scores of Groups I	II	III	Total Score	Group Order of Choice I	II	III	Times Chosen Best	Worst
VIII	Steamed	52	3.5	5.0	6.0	212	6	6	6	4	0
	Bisulfite		7.0	8.0	8.3	385	1	1	3	22	0
	Bought dry		-7.4	-4.0	-4.5	-336	7	7	7	0	47
	Canned		5.0	5.2	8.5	286	5	5	2	5	2
	Fresh sweet		5.4	6.3	8.0	308	4	2	4	5	1
	Frozen		6.0	6.1	8.8	342	2	3	1	8	0
	Fresh plain		6.0	6.1	7.6	333	2	3	5	8	2
IX	2 hrs. cold	55	8.3	8.4	8.3	460	2	1	1	17	8
	½ hr. "		8.2	7.5	8.8	449	1	3	1	14	4
	No soaking cold		7.6	6.8	7.5	309	5	3	3	3	12
	2 hrs. hot		7.6	7.2	8.3	420	5	2	2	6	13
	½ hr. hot		7.8	7.0	7.0	418	4	3	3	5	11
	No soaking hot		8.0	7.0	9.8	441	3	3	2	10	7
X	Lemon, fresh	55	7.2	8.3	8.6	422	2	2	2	14	4
	Cinnamon, fresh		5.7	7.3	7.3	351	1	1	3	19	4
	Plain, fresh		7.4	7.9	9.5	428	2	3	1	15	4
	Lemon, Dry		2.2	5.2	4.5	177	5	6	3	1	19
	Cinnamon, Dry		2.9	5.4	5.5	209	4	4	2	4	12
	Plain, Dry		1.7	5.4	6.0	166	6	4	2	2	12

least desirable as often as it was chosen as best, whereas when sugar was added it was preferred twenty-five times to the once that it was considered least desirable. The principal objection to the unsweetened sample was that it lacked distinctive flavor or was flat. Inconsistency appeared in the score values assigned and the rating by choice with the plain sample. Because of the difficulty of providing enough sugar for all the tests, the lack of definite dislike of unsweetened apple sauce and the preference for it shown by experienced judges, it was decided to try the next test without sugar. Salt was definitely undesirable.

TEST II. The method of cooking dried apples was the first point considered. Because the preliminary tests had shown that the proportion of water to apples of six to one by weight was most desirable, that less water resulted in an apple sauce too thick and likely to scorch, and more gave a sauce thinner than the standard fresh apple sauce, this proportion was used throughout. These preliminary tests had also indicated the desirability of cooking the apples at a low boil, but the evidence was meager. This test was undertaken to clarify the point. The time required to obtain a tender enough product to strain was also to be standardized for subsequent tests.

The samples chosen for the experiment were Lot I, sulfured, pretreated according to the most universally suggested method and one of the most attractive looking, and Lot V, steamed blanched four minutes, one of the darker colored lots.

The difference in pretreatment was found to be a major factor in results, masking any difference due to cooking procedure, when the four samples are considered together. Color had the greatest effect on choice, even in the experienced group. But the color preference varied, Group I and II choosing the light samples, and Group III the dark samples. However when the sulfured and blanched samples are considered as two different tests the situation is somewhat clarified.

The average scores for sulfured apples indicated that boiling was preferred to simmering by Group I, in Group II the values were about the same and Group III preferred simmering. However, the total points scored were greater for boiling. By choice, simmering was preferable. In the blanched samples higher scores prevailed throughout for boiling, and Groups II and III also placed that sample higher than the simmered apples by choice. With both types of apples the boiled samples were considered least desirable fewer times than the simmered apples.

Since boiling was definitely preferred for the more undesirable samples, and there was lack of unanimous preference for simmering with desirable samples, it appeared that boiling would be a wise choice for general cooking procedures with different types of dried apples, the desirability of some of which was questionable.

Twenty minutes cooking was enough to produce a tender but not over cooked product, and this time was adopted as standard for future tests.

TEST III. Although the principal purpose of this test was to study the effect of time of soaking on palatability some information on the rate and extent of rehydration was also gathered. The data on rehydration appear in Table VI. The rate at which water is absorbed in half an hour is somewhat less than twice the water absorbed in fifteen minutes and so on. Dehydrated apples that have been soaked and cooked in the same water had absorbed more water by the end of the cooking period than those cooked without soaking, which might be of importance in some methods of preparation.

TABLE VI

Water Absorbed During Refreshing

	Time	Weight		
		Apples	Water absorbed	
Cold Water		grams	grams	
60 grams of	1 hour soaking	173	113	
apples and	2 hour soaking	203	143	
360 grams	After cooking	255	195	
cold water	1 hour soaking	172	112	
Test III	After cooking	260	200	
	1/4 hour soaking	123	63	
	1/2 hour soaking	145	85	
	After cooking	226	116	
	Cooked without soaking	198	138	
				Water absorbed on 60 gram basis
Hot Water	1 hour soaking	271	191	143
80 grams of	2 hour soaking	305	225	169
apples and	After cooking	322	242	182
480 grams	1 hour soaking	296	216	162
of boiling	After cooking	317	237	178
water	1/4 hour soaking	208	128	96
Test V	1/2 hour soaking	238	158	119
	After cooking	348	268	199
	Cooked without soaking	263	183	137

In apple sauce where pulp and juice are used together it is of no importance. Cooking time was not decreased by soaking.

Group I rated the apples cooked without soaking and those soaked one hour as equally desirable, while Group III rated those soaked one hour and two hours as equal but less desirable than when only half an hour's soaking was given. According to total scores one hour soaking gave a slightly more desirable product than no soaking, both being definitely higher in rating than the samples not soaked or soaked two hours. Those that ranked first according to the number of times chosen most desirable by each group were the ones which received the highest numerical scores but when the choices of the two groups were combined no soaking ranked first. However it was also rated as least desirable the greatest number of times. The three soaking periods were each chosen "best" about an equal number of times, but half an hour soaking was least often voted undesirable. This test was remarkable for the inconsistency of the individual score cards. Ten of the judges contradicted themselves and most of them varied the points given for color and odor in such a manner that it appeared they were searching for differences which did not actually exist. One would conclude that for the dried apples in this test, which were from Lot I, sulfured, and one of the most desirable lots, soaking as long as two hours, or not soaking at all, made no difference in the desirability of the apple sauce and did not lead to a saving in cooking time.

TEST IV. In this test the final results were clear cut and consistent. The recently dehydrated apples treated with salt solution and steam blanching were rated most desirable by all groups, both by scores and choices, and apples treated by the same method but stored eight months were ranked least desirable. Dehydrated apples treated with only the salt solution dip, though not as palatable when new, stood up better in storage than those which were also blanched. Both the old and the new lots were prepared from the same variety of apples. The stored apples had darkened noticeably but their general appearance was not unattractive. A considerable number of the judges noticed the flavor of salt in the blanched and stored apples and in the new salt dip lot. Apparently blanching is not a desirable method of pretreatment as it does not yield a product that "holds up" in storage. Salt solution dip however, cannot be recommended highly because of inferiority of flavor when new.

TEST V. Since soaking in hot water has been recommended by Woodroof as the quickest and best method of rehydration these tests were made. As the supply of apples sulfured by burning powdered sulfur was running short the lot sulfured by means of the sodium bisulfite dip was used for these experiments.

The rate of refreshing judged by the increase in weight of the apples, which was due to the water absorbed, was much more during the first hour, especially during the first half hour, than when cold water was used, as may be seen by comparing figures in Table VI. Rehydration was finally no more complete than when preliminary soaking was in cold water.

Group I preferred the sample soaked one hour, with that soaked two hours a close second according to points, and reversed the order of these two in their choice of best. Group II gave the highest score value to the sample soaked half an hour, with one hour second, and reversed their order in the selection by choice. Group III also gave the highest score to the samples soaked half an hour, and corroborated this preference by their choice of best. However the total score, being heavily weighted by the number in Group I, was in favor of the one hour soaking. Also the total choices for best were greater and the number of times it was rejected fewer. With this sample a number of the judges noticed the sulfur, and the soaking before cooking apparently aided in its displacement during cooking. This would indicate the advisability of soaking dehydrated apples pretreated by this method, apparently from half to one hour being sufficient.

There was no measurable difference in cooking time.

TEST VI. The three lots of blanched apples which were decidedly darker than the other lots of the ten pretreatments were separated for tasting tests because of the influence of color on the judgment of flavor.

The groups were consistent in their scoring, but Group II varied in preferring the seven minute blanch instead of the four minute blanch which was the choice of Groups I and III. The total score and total times chosen best definitely placed the four minute blanch as the most desirable.

Sulfuring after blanching did not improve the color and had a deleterious effect on flavor. Although, from the results of Test V, it was considered best to soak these samples one hour in case the sulfur should affect flavor, an "off" taste was prominent. Sulfuring following blanching has nothing to recommend it.

TEST VII. The best of the steam blanched lots as chosen in Test VI, i. e. Lot V, blanched four minutes, all the other lots except those steam blanched, namely, Lots I, II, VII, VIII, and IX, and fresh apple sauce made from Winesaps, were compared, all being served at the same time. The judges found this rather a large number of samples to handle but the scoring was no more inconsistent than usual and the results were definite and consistent.

The sample pretreated with sodium bisulfite was rated first by both groups participating and by both means of scoring. Second preference was for apples blanched ten minutes in syrup according to scores of both groups, but not according to the number of times it was chosen most desirable. The apples treated with sulfur fumes were second according to choice, but third according to total points scored and to the score of Group I, however Group II put it in fifth place according to points. The fresh apple sauce was not recognized as such and ranked low both in score values and in choices. The least desirable sample was the one pretreated with salt solution dip only.

It is to be concluded from this test that the pretreatment of apples that yields the most desirable dehydrated product is the sodium bisulfite dip, and dehydrated apples pretreated by sulfuring or steam or syrup blanching compare favorably with fresh apple sauce.

TEST VIII. The judges in Groups I and II chose the dehydrated apples pretreated with bisulfite solution in preference to any other sample, but the staff chose frozen apple sauce as best, canned as second best, and the bisulfite treated apples were given third place. There was in fact very little to choose between these samples, all being ligh colored and well flavored. Groups I and II placed fresh and frozen apple sauce second, but Group II preferred the fresh sauce sweetened. Undoubtedly the least desirable was the sun dried sample, which was very dark and tasted strongly of sulfur.

If properly pretreated, dehydrated apples are as good as or better than the highly praised frozen product, but the retail market makes this a hard point to put over because of the unattractive dehydrated products which it offers.

TEST IX. These tests indicate that there is very little to choose between soaking in hot or cold water, for as long as two hours or not at all. The difference in score values is not great but Groups I and II gave the highest to the sample soaked two hours in cold water, while Group III rated highest the one not soaked at all but cooked at once in boiling water. The total score was of course heavily weighted by Groups I and II to give first place to their own preference. However, none of the samples received low ratings. When the number of times a sample was chosen best is considered, the samples soaked either one half or two hours in cold water seems to be preferable.

The judges frequently referred to color, texture and sweetness or bitterness in their comments, but with no consistency, and apparently without a great deal of attention to the score values they assigned. However, it may be concluded that soaking in cold water for from one half hour to two hours is as good as or better than soaking in hot water or cooking without soaking.

TEST X. The flavorings chosen were those most frequently suggested for use with apples. They did not serve to disguise the poor flavor of this lot of dehydrated apples, and confirm the principal that to produce a good product the preparation must be done by the best methods from the beginning, rather than attempting to doctor up a poor product.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

An investigation has been made of factors which influence the flavor of dehydrated apples and of methods most desirable for home dehydration.

The experiment was begun by dehydrating hand picked Stayman Winesaps in a cabinet designed for home use. The following pretreatments were used: sulfuring, blanching in steam seven minutes, blanching in steam until translucent, (four minutes), blanching in steam until translucent (five minutes) and sulfuring, blanching in boiling syrup ten and twenty minutes, dipping in salt solution, in salt and sugar solution, and in sodium bisulfite solution, and salt solution dip followed by steam blanching. Following dehydration, tests were made of the effect on palatability of rate of cooking, time of soaking before cooking, temperature of soaking water, pretreatment and added flavoring. The effect of eight months storage on samples pretreated by salt solution dip, and this dip followed by steam blanching, was also studied.

The products were scored by three groups of judges, one group without training in foods work, consisting of thirty-seven sophomores, a second group with some training, made up of twelve advanced students, and a third group of seven staff members who were experienced in foods work.

It was found that the experienced judges were not significantly more consistent in their scoring than the inexperienced ones. In the ten tasting tests eighteen per cent of the score cards of the inexperienced judges showed inconsistencies in scoring, and sixteen per cent of those of both the experienced groups were inconsistent. Where a difference among samples was marked the conclusions reached were in general the same for all groups. The student judges appeared to have a liking for more distinct flavors, tending to prefer sweetened samples to plain, and showing less discrimination against samples where sulfur and salt flavors were noticeable than the staff, most of whom preferred more delicate flavors. Experience did not seem to be an aid in differentiating between samples where differences were very small, as in studies of refreshing, probably the acuity of taste of the individual being a more important factor. The inexperienced judges were more likely to be influenced by extraneous factors.

It was found that the easiest and quickest methods of pretreatment were the dips; sulfuring is not difficult but requires more time; blanching procedures are the most difficult and time consuming and require more experience.

Cooking and refreshing procedures play a relatively small part in the palatability of dehydrated apples. Samples which have been pretreated with sulfur are more certain of being freed from it during cooking if soaked for from one half to two hours beforehand. Soaking should not be continued for longer than two hours.

Pretreatment is the most important factor in maintaining palatability and general attractiveness. Sodium bisulfite dip was found to be the most desirable method of pretreatment, from the standpoint of both palatability and general attractiveness in appearance. It is also an easy and inexpensive method.

Other pretreatments that give products comparing favorably with fresh apples for the preparation of apple sauce are sulfuring and blanching, in steam or syrup, until translucent. These methods are not as advantageous in economy of time and labor as the bisulfite dip.

In storage the apples pretreated with a salt solution dip retained their flavor better than those steam blanched after the dip, although initially this flavor had been less desirable. Therefore neither of these methods can be highly recommended for apples. The effect of storage on other samples could not be determined due to shortage of time.

It is recommended that further study be made of the effects of storage on apples dehydrated by home methods, food value, as well as palatability, being considered.

Directions provided for the public should be simple, emphatic and consistent. More stress should be given to the importance of selecting sound fruit and of using a suitable method of pretreatment, preferably the bisulfite dip, so that the finished product may compare favorably with the canned and frozen fruits.

It is also recommended that cabinets for home dehydration be improved in design for efficiency of insulation and reduction of purchase price.

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

Child, Alice M., and Niles, Katherine B. Food Preparation Studies. New York: John Wiley and Son Inc., 1938. 157 pp.

Cruess, William V., Joslyn, M. A. and Mackenney, Gordon. Adapting Fruit and Vegetable Products to War Needs. Berkeley, California: University of California Press, 1942. 38 pp.

Duncan, A. O. Food Processing. Atlanta, Georgia: Turner E. Smith Company, 1943. 540 pp.

Nason, Edith H. Introduction to Experimental Cookery. New York: McGraw-Hill Book Company, Inc., 1939. 308 pp.

Von Loesecke, Harry W. Drying and Dehydration of Foods. New York: Reinhold Publishing Corporation, 1943. 282 pp.

Bulletins

Buttrill, Martha W. and Ridout, W. J. Jr. Home Dehydration. Circular No. 243, Clemson, South Carolina: Clemson Agricultural College, 1943.

Caldwell, Joseph S. Farm and Home Drying of Fruits and Vegetables. Bulletin No. 948, Washington, D. C.: United States Department of Agriculture, 1933.

Chace, E. M. The Present Status of Food Dehydration in the United States, A. C. E. 172, Washington, D. C.: United States Department of Agriculture, 1942.

Cruess, W. V., Faust, Hilda, and Greaves, Vera D. Drying of Vegetables and Fruits in the Home. Berkeley, California: College of Agriculture of the University of California, 1943.

Curtis, Lavada. Drying Fruits and Vegetables in the Home. Circular No. 139, Auburn, Alabama: The Alabama Polytechnic Institute, 1933.

Davis, Eleanore, and Bedford, C. L. Drying of Fruits and Vegetables At Home. Bulletin No. 314, Pullman, Washington: Washington State College, 1944.

Davis, Gilbert S. and Esselen, William B. Jr. Home Dehydration of Vegetables. Bulletin No. 404, Amherst, Massachusetts: Massachusetts State College, 1943.

Eidt, C. C. Principles and Methods Involved in Dehydration of Apples. Publication No. 625, Bulletin No. 18. Kentville, Nova Scotia: Experimental Station, 1938.

Garvin, Alma L., Thompson, Nelle and Junnila, W. A. Home Drying of Fruits and Vegetables. Columbus, Ohio: Ohio State University, 1943.

Hobart, Inez. Drying Foods at Home. Pamphlet No. 102, St. Paul, Minnesota: University of Minnesota, 1943.

Long, J. D., Mrak, E. M. and Fisher, C. D. Investigations in the Sulfuring of Fruits for Drying. Bulletin No. 636, Berkeley, California: University of California, 1940.

Neely, Grace I. Drying of Foods at Home. Circular No. 170, College Station, Texas: Agricultural and Mechanical College of Texas, 1941.

Prudent, Inez and Wright, Forrest B. Drying Fruits and Vegetables at Home. Bulletin No. 618, Ithaca, New York: Cornell University, 1941.

Public Service Company of Northern Illinois, The Department of Home Economics. Home Dehydration With a Gas Oven. Chicago, Illinois, 1943.

Pyke, W. E. and Charkey, L. W. Making and Using A Food Dehydrator. Bulletin No. 477, Fort Collins, Colorado: Colorado State College, 1943.

Richardson, Jessie E. and Mayfield, Helen L. Some Methods of Fruit Preservation in Wartime. Circular No. 173. Bozeman, Montana: Montana State College, 1943.

Scholz, Ruby. Home Drying of Fruits and Vegetables. Circular No. 232, Raleigh, North Carolina: North Carolina State College, 1943.

Schroeder, W. and Link, Conrad B. A Community Dehydrator. Bulletin No. 448, State College, Pennsylvania: Pennsylvania State College, 1943.

Sheets, Olive. Home Dehydration Affects the Nutritive Value of Fruits and Vegetables. Circular No. 113, Starkville, Mississippi: Mississippi State College, 1943.

Shuey, G. A. Dehydration of Fruits and Vegetables In the Home. Bulletin No. 183, Knoxville, Tennessee: University of Tennessee, 1943.

Simon, Mildred. Dehydrated Foods and Their Preparation. Circular No. 262, Auburn, Alabama: Alabama Polytechnic Institute, 1943.

Tarrant, Lydia and Winters, Eleanor B. Drying Fruits and Vegetables at Home. Circular No. 247, State College, Pennsylvania: Pennsylvania State College, 1943.

Tressler, Donald K. Home Dehydrators and Home Dehydration. Pamphlet from General Electric Review No. 47, New York: 1944.

United States, Department of Agriculture. Commercial Dehydration of Vegetables and Fruits in Wartime. Miscellaneous Publication No. 524, Washington, D. C.: The Department, 1943.

————. Drying Foods For Victory Meals. Farmer's Bulletin No. 1918. Washington, D. C.: The Department, 1942.

Wiegand, E. H. and Onsdorff, Holmes Alyce. Home Fruit and Vegetable Dehydration. Circular No. 149, Corvallis, Oregon: Oregon State College, 1943.

Woodroof, J. E. DuPree, W. E. and Thompson, Helen H. Dehydration of Fruits and Vegetables and Utilization of Dehydrated Products. Bulletin No. 225, Experiment, Georgia: University of Georgia, 1943.

Periodical Articles

"Army Now Buying Dehydrated Apple-Nuggets" Editoral. The Fruits Products Journal, XXI (May 1942), 279.

Batchelder, E. L. "Home Drying Methods and Their Effects On the Palatability, Cooking Quality, and Nutritive Value of Foods." American Journal of Public Health, XXXIII (August 1943), 94-97.

Brinkman, E. V. S. and others. "Effect of Various Cooking Methods Upon Subjective Qualities and Nutritive Values of Vegetables." Food Research, VII (July-August 1942), 300-305.

Crocker, E. C. "Food Flavors - A Critical Review of Recent Literature." Food Research, II (March 1937), 163.

————. "Measuring Food Flavors." Food Research, II (March 1937), 286-273.

————. "Seeking a Working Language for Odors and Flavors." Industrial Engineering Chemistry, XXVII (October 1935), 1225.

Cruess, William V. "Dehydration of Foods In Wartime." The Fruit Products Journal. XXII (December 1942), 105-107; 118.

————. "Some Observations on Dehydration." The Fruit Products Journal, XXII (May-July 1943), 265-268; 300-302; 331-333.

———— and Mrak, E. M. "The Dehydration of Vegetables." The Fruit Products Journal, XXI (July 1942), 337-340.

Fabin, F. W. and Blum, R. B. "Relative Taste Potency of Some Basic Food Constitients and Their Competitive and Compensatory Action," Food Research, VIII (May 1943), 179-193.

Farrell, Kenneth T. "Commercial Dehydrated Foods." Journal of Home Economics, XXXVI (January 1944), 16-17.

Fenton, F. and Gifft, H. "Palatability Studies of Commercially Dehydrated Vegetables." Food Research, VIII (September 1943), 364-376.

Fisher, Katherine. "Questions and Answers on Dehydrated Foods." Good Housekeeping, CXVII (August 1943), 87.

Friar, Hazel and Mrak, E. M. "Dehydration of Huckleberries." The Fruit Products Journal, XXII (January 1943), 138-139; 156.

Gray, L. M. "Performance of Small Domestic Dehydrators." Agricultural Engineering, XXIV (May 1943), 164.

Henderson, C. E. "A Report On Home Dehydration of Food Products." Agricultural Engineering, XXV (February 1944), 52-55.

Hightower, Grace. "The Food Comes First In Package Design." Food Industries, XVI (March 1944), 73.

Howard, Jonas. "Home Dehydration of Fruits." American Fruit Grower, LXIII (August 1943), 7.

Kable, George W. "Small Dehydrators for Farm Use." Agricultural Engineering, XXIV (August 1943), 263-264.

King, Florence B. "Obtaining A Panel For Judging Flavor in Food." Food Research, II (March 1937), 207-219.

Mackinney, G. and Friar, H. F. "Sulfured Dehydrated Vegetables." The Fruit Products Journal, XXII (June 1943), 294; 315.

Melnick, M. Hochberg, and Oser L. B. "Comparative Studies of Steam and Hot Water Blanching." Food Research, IX (March-April 1944), 148-153.

Mrak, E. M. "Development in Dehydration." Journal of the American Dietitic Association, XIX (January 1943), 6-11.

Mrak, E. M., and others. "Dehydration of Fruits Offers Important Wartime Advantages." Food Industries, XV (April 1943), 59-62.

Perkins, Marion S. "A Brief Resumé of Fruit Drying and Packing." The Fruit Products Journal, XXII (November 1942), 75-76.

Stillman, J. T., Watts, Betty M. and Morgan, Agnes F. "Palatability Studies On Home Dehydrated Vegetables. Journal of Home Economics, XXXVI (January 1944(, 28-34.

Sweetman, Marion D. "The Scientific Study of the Palatability of Food." Journal of Home Economics, XXIII (February 1941), 161-171.

Talbot, Elizabeth Abby. "Save What You Can't Eat." The American Home, XXXII (July 1944), 62-63.

Watts, Betty M. "Pretreatment of Foods for Dehydration." Journal of Home Economics, XXXVI (January 1944), 13-15.

————. "Flavor In Food." Journal of Home Economics, XXXI (December 1939), 673.

Woolrick, W. R. "The Romance and Engineering of Food Preservation." Science, LXXXXIX (February 1944), 107-113.